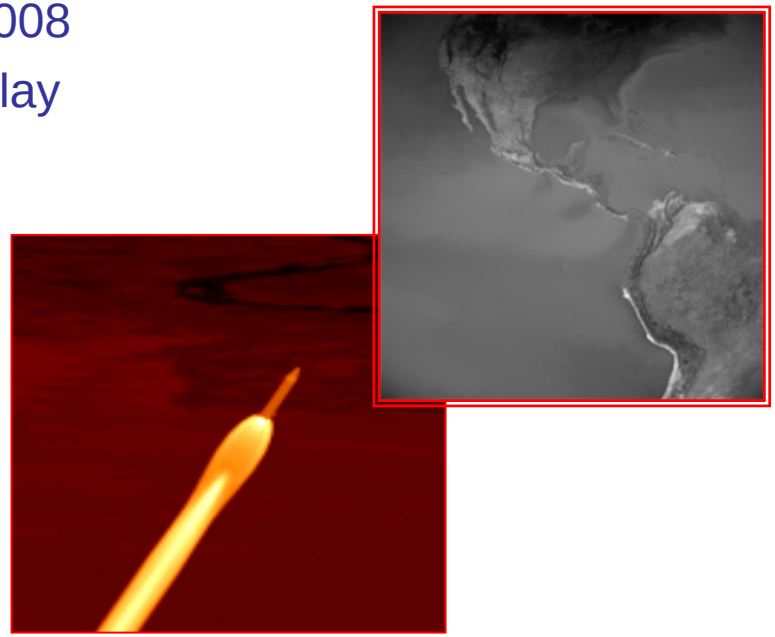
Modeling, Simulation, and Phenomenology Research Area

MDA SBIR Industry Day

7 August 2008

Carol Barclay



Modeling, Simulation, and Phenomenology Research Area Scope and Objectives

- **Objectives**
  - Technological Innovations in Modeling & Simulation (M&S)
  - Support Development & Testing of the Ballistic Missile Defense System (BMDS)
- **Research Area Scope**
  - Enhancements in Propulsion Related Modeling
  - Optimization of Ballistic Missile Defense System Level Modeling
  - Development of Unified, Consistent Background Modeling
  - Signature Prediction and Uncertainty Analysis for MDA Radar-based Applications
- **BMDS Relevance**
  - Enhanced signature prediction capability for active and passive EO and RF sensors used in BMD elements and systems supports test planning, test target design, sensor design/development/test, data and system analysis, operational test and evaluation, and algorithm development
  - Optimization of the Ballistic Missile Defense System through system level modeling using advanced optimization algorithms and techniques

Modeling, Simulation, and Phenomenology Research Area Topics

Topic	Sponsors	TPOCs
MDA-08-032 Integrated UV/VIS/IR background phenomenology models for radiation transport system trades	DE	James Brown, AFRL Jules Goldspiel, NRL
MDA-08-033 Exploitation of Alternative Wavelengths for Propulsion Related Signature Events	AB, GM, KI, SS, MK, SN, DE	Thomas Smith, AFRL Carol Barclay, MDA
MDA-08-034 Enhancements to Continuum Plume Flowfield Models for Transitional Flow Simulations	AB, GM, KI, SS, MK, SN, DE	Thomas Smith, AFRL Carol Barclay, MDA
MDA-08-035 Signature Prediction and Uncertainty Analysis for Radar-based MDA Applications	DE	Eric Branch, AFRL
MDA-08-036 Ballistic Missile Defense System-Level Simulation Optimization	DE	Alan Jacobs, MDA

Phenomenology Topic – MDA-08-032

Integrated UV/VIS/IR background phenomenology models for radiation transport system trades

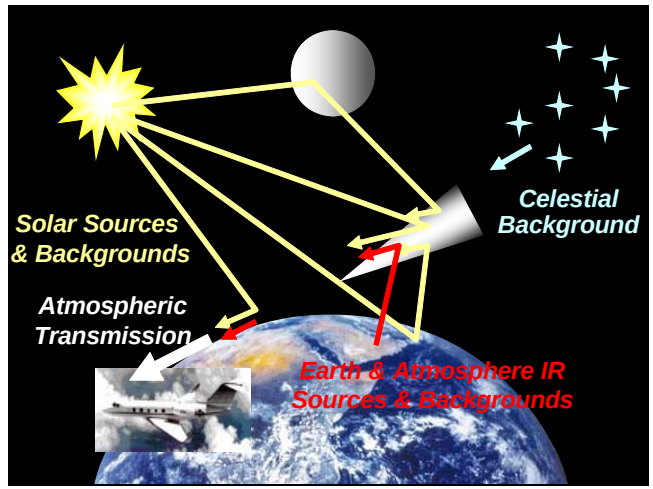
Modeling and Simulation Directorate

TOPIC: Integrated UV/VIS/IR background phenomenology models for radiation transport system trades

OBJECTIVE: *Develop advanced software algorithms and architecture to create integrated, unified and consistent terrain and cloud background models for battlespace ultraviolet, visible and infrared system trade studies.*

Proposals are sought for developing an innovative capability to improve terrain and cloud simulations and integrate the new models into state-of-the-art background radiation codes, such as the Air Force SAMM2 and FLITES codes and Navy SSGM code to meet missile warning/defense surveillance needs.

Proposed advances should address issues related to determining the state of the terrain and clouds from UV, VIS and IR imagery, using arbitrary spatial resolution that is commensurate with, but not limited to, airborne and satellite imagery, and producing simulations as seen by UV, VIS and IR sensors through radiative transfer modeling.



Topic POC: James H. Brown/AFRL

2nd Topic POC: Jules Goldspiel/NRL

Phenomenology Topic – MDA-08-033

Exploitation of Alternative Wavelengths for Propulsion Related Signature Events

Objective:

- The objective of this effort is to innovatively extend the capabilities of existing propulsion related signature tools to characterize emission phenomena over a broad portion of the electromagnetic spectrum, from the ultraviolet (UV) through the long wave infrared (LWIR)

Capabilities Desired:

- Full exploitation of passive signature features relevant to the current and future BMDS architectures
- Complete full characterization of relevant propulsion events such as plumes, fuel vents, particle trails, and solid rocket motor chuffing

Phase I Goals:

- For one propulsion related signature event observable of interest, identify the chemical and physical phenomena required to model and properly account for the complete process and prioritize the importance of each component as a function of altitude, velocity, and spectral band
- Select one important complex component and demonstrate an innovative methodology (theoretical or experimental) to solve for that component unknown.
- If possible, demonstrate this complex component upgrade within the existing MDA/DESH propulsion related signature tools

Phenomenology Topic – MDA-08-034

Enhancements to Continuum Plume Flowfield Models for Transitional Flow Simulations

Objective:

- Investigate innovative methods to extend the capabilities of continuum plume codes to predict the near-transitional flow regime with increased fidelity as well as greater computational efficiency, stability, and robustness

Capabilities Desired:

- Extend the computational capabilities of CFD methods beyond the classical continuum breakdown thresholds while limiting degradation to the overall accuracy

- Maximize use of existing plume software for continuum flow regimes to reduce development and validation costs

Phase I Goals:

- CFD models should demonstrate the capability to simulate the exhaust plume flowfield and IR signature at 150 km for at least two high thrust boosting systems (30,000 – 200,000 lbf), one of which uses an aluminized solid propellant.

- Identification of techniques for both diffusing species into low density environments as well as incorporation of non-local thermal equilibrium chemistry will be required.

Phenomenology Topic – MDA-08-035

Signature Prediction and Uncertainty Analysis for Radar-based MDA Applications

Modeling and Simulation Directorate

- **Objective**
  - Develop physics-based radar signature prediction methods and uncertainty analysis techniques for MDA objects of interest
- **Technology Areas of Interest**
  - Computational Electromagnetics: Efficient computation of the radar scattering from MDA objects of interest (MOIs)
  - Uncertainty: Calculate the effects of geometric and material uncertainties on radar signatures without relying on inefficient methods (e.g., Monte Carlo)
- **Key Performance**
  - Plots or tables of the accuracy and compute time showing improvement over present methods
- **Phase I Goals**
  - Development of a novel and efficient physics-based CEM algorithm for predicting the electromagnetic scattering from MOIs.
  - Proof of concept of a method for including object variability and uncertainty in radar signature predictions
- **BMDS Relevance**
  - Identification of threats (and the separation from countermeasures/non-threats) would increase the effectiveness of a BMDS
  - Characterization of the uncertainty of the signatures will help to optimize the performance of automatic object recognition systems

Modeling, Simulation & Phenomenology Topic – MDA-083-036

Ballistic Missile Defense System-Level Simulation Optimization

Objective:

- Design and build software providing an efficient and effective capability to integrate with and control existing medium-to-high resolution, dynamic Ballistic Missile Defense System-level (BMDS-level) simulations to determine optimum parameters of offensive scenario design, BMDS architecture design and/or Warfighter's operational decisions

Capabilities Desired:

- Innovative or creative approaches to a BMD System-level simulation optimization capability
- Accommodate both deterministic and stochastic ("Monte Carlo") BMDS simulations with optimization over 10^4 order-of-magnitude continuous, discrete or both types of decision variables
- Optimize MOE and explicit constraint functions that may be discontinuous and otherwise nonconvex
- Software/systems engineering approach to integrate readily with existing BMDS simulations
- Exhibit runtime performance compatible with MDA analysis processes (reasonably a few hours)

Phase I Goals:

- Develop and demonstrate "proof-of-concept" of an overall BMDS simulation optimization capability approach that includes algorithm(s), supporting rationale/mathematical analysis, system/software integration concept

Questions?